

***In vitro* evaluation of apical microleakage following canal filling with a coated carrier system compared with lateral and thermomechanical gutta-percha condensation techniques**

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Abstract

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Aim The apical sealing ability of a coated carrier system was evaluated in extracted human teeth and compared with lateral and thermomechanical condensation techniques using dye penetration.

Methodology Sixty-four extracted single-rooted teeth were instrumented to an apical size 30 using 4% taper Hero 642TM instruments (Micromega, Besançon, France). The sample was divided into three experimental groups. Twenty teeth were randomly obturated with lateral condensation, 20 with thermomechanical compaction and 20 teeth with the HerofillTM Soft-Core system. Four teeth were used as positive and negative controls. The teeth were covered with nail varnish up to 2 mm from the apical foramen and immersed in a 2% aqueous methylene blue dye solution for 1 week and then washed, dehydrated and

embedded in resin. The apical 1 mm of each tooth was removed to reveal the apical limit of the preparation. Transverse sections of the teeth were taken at 500, 1000 and 1500 µm from this point and evaluated for apical leakage. Significant differences between the preparations were analysed with a semiautomatic analyser and the ratio of the dye-penetrated surface to the total dentinal surface was calculated.

Results Statistical analysis of the results demonstrated significantly less leakage for the HerofillTM Soft-Core system compared to lateral condensation in terms of total mean dentinal surface and at the 500 µm level. No other differences were noted between HerofillTM Soft-Core and thermomechanical or lateral condensation, either for the total mean value or at each level.

Conclusion The HerofillTM Soft-Core system was a reliable obturation system in the apical portion and compared favourably with other gutta-percha filling techniques.

Keywords: apical leakage, endodontics, HerofillTM Soft-core obturation, root-canal filling.

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Introduction

HerofillTM Soft-Core obturators (Micro-Méga, Besançon, France) consist of plastic carriers coated with thermoplastic α -phase gutta-percha. The central carrier has an ISO standard size and the system provides a size verifier that ensures adequate preparation of the canal

and the selection of the corresponding HerofillTM Soft-Core obturator. The taper and shape of the system have been designed to complement the Hero 642TM nickel-titanium rotary instrument. The obturators have a 2% taper and are available from size 20–100. All obturators and verifiers are 25 mm long. The system is completed with a small portable oven (HerofillTM oven) that enables warming of the gutta on the obturators.

The HerofillTM Soft-Core system is comparable to ThermafilTM (Dentsply Maillefer, Ballaigues, Switzerland); both belong to the carrier obturation systems and involve thermoplasticized gutta-percha as a coating on

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a flexible carrier. The sealing ability of the Thermafil system has been evaluated in several *in vitro* studies with variable conclusions; although, overall, it seems to provide a comparable sealing ability to cold, warm or hybrid condensation of gutta-percha. Recently, De Moor & Hommez (2000) compared Thermafil™ and Soft-Core™ systems with condensation techniques; Soft-Core™ allowed greater apical leakage than other techniques.

The purpose of this *in vitro* study was to evaluate the apical leakage and the sealing ability of the Herofill™ Soft-Core system and to compare it with cold lateral and thermomechanical gutta-percha condensation.

Materials and methods

Preparation and filling of the root canals

Sixty-four extracted single-rooted teeth were selected and stored in a 5% sodium hypochlorite solution for 20 days. All teeth were radiographed on the buccal and proximal views to check for a single root and single canal. Endodontic access was prepared conventionally and the canal system prepared using Hero 642™ instruments following a standard protocol (Vulcain & Calas 1999, Thompson & Dummer 2000). Working lengths were calculated using a size 10 file until its emergence at the apical foramen and then subtracting 1 mm. All canals were enlarged with a 6% taper size 30 Hero instrument in the coronal two-thirds, then with a 4% taper size 30 instrument to the working length; apical patency was confirmed with a size 15 K-file. Canals were irrigated with 5 mL of 2.5% NaOCl solution using a 27-gauge endodontic needle after each instrument passage. Following preparation, the canal was rinsed with 3 mL of a 17% EDTA solution for 30 s, followed by 5 mL of a 2.5% NaOCl solution. The canal was subsequently dried with sterile paper points.

The sample was randomly divided into three groups of 20 teeth:

Group 1: Teeth were obturated using the Herofill™ Soft-Core obturators (size 30); a thin coating of the endodontic sealer (Sealite Regular, Pierre Rolland, Bordeaux, France) was manually deposited in the coronal portion of the canal with the size 30 verifier. After the Herofill™ Soft-Core obturator was heated for 35 s in the Herofill™ Soft-Core oven, it was seated to the working length. The handle of the obturator and excess material in the chamber were removed after cooling with a small round bur (Thermacut, Dentsply Maillefer, Ballaigues, Switzerland).

Group 2: Teeth were obturated using a cold lateral condensation technique. A size 30 gutta-percha cone was

inserted to the working length and a tight fit-assured. The master cone was coated with the same sealer, gently seated in the canal and condensed with a spreader. Accessory gutta-percha cones were inserted until they could not be introduced more than 3 mm into the root canal. After warming the coronal material was vertically condensed with an endodontic plugger size 4 (Dentsply Maillefer).

Group 3: Teeth were obturated using a thermocompaction technique; the sealer was placed in the canal as described above. A size 30 master cone was fitted at the working length and the size 30 gutta-percha condensor (Dentsply Maillefer) was inserted into the root canal alongside the master cone without rotation to 2–3 mm from the working length. Rotation of the condensor commenced at 5000–8000 r.p.m. with the condensor being maintained in the same position for 1 s and then slowly withdrawn from the canal as rotation continued. Excess gutta-percha was removed from the canal orifice and the remainder was vertically condensed with a size 4 manual plugger (Dentsply Maillefer).

The access cavities of all teeth were obturated with a composite resin (Tetric, Ivoclar, St Jorioz, France) to ensure a coronal seal. Two layers of nail varnish (L'Oréal, Paris, France) were applied to the surface of each tooth except the apical 2 mm, so that tracer could penetrate the canal via the apical region only.

Dye-leakage experiment

Each tooth was subsequently immersed in a freshly prepared 2% aqueous methylene blue dye solution, in an individual vacutainer for 7 days. Teeth were then rinsed in tap water to remove excess dye and then subsequently dehydrated in a series of graded ethanol and maintained for 15 min in a 95% ethanol bath. Teeth were rinsed in acetone for 20 min to elute the varnish and embedded in Epon B (Glycidyl Ether 100 and Methyl Nadic Anhydride, MNA) polymerized for 48 h at 48°C by addition of *N*-*N*-benzyl dimethyl amine (BDNA).

Sectioning of the teeth was carried out with a Buehler Isomet sawing machine and a diamond wafering blade (Buhler series 15HC, n°11–214, 10.2 cm diameter and 0.3 mm thickness); the first transverse section involved the removal of 1 mm of root at the apical foramen to the limit of the apical preparation. The teeth were subsequently cut at 500, 1000 and 1500 µm from this limit, then dehydrated and mounted with Eukitt resin for microscopic observation (Wild MPS 50, Heerbrugg, Switzerland) of the coronal surface of the preparation.

Assessment of dye leakage

Dye penetration was estimated as the ratio of the methylene blue-infiltrated surface divided by the total dentinal surface. Leakage data were recorded for each obturation technique and the average ratio was calculated in each group of 20 teeth. Dentinal infiltration surface was measured with a semiautomatic analyser. Each slice was observed under the microscope ($4\times$ magnification) and the infiltrated dentine surface was outlined with a digital laser pointer prior to measurement. Total dentinal surface was recorded and the ratio of infiltrated surface/total dentinal surface of each slice was calculated.

Statistical analysis

Data were normally distributed and statistical analysis was performed using the non-parametric Mann-Whitney *U*-test. This enabled the comparison of the apical leakage between the three obturation techniques, and for each slice level at 500, 1000 and 1500 μm from the apical limit of the preparation.

Results

A higher infiltration ratio was noted for the lateral condensation technique (22.28%) as opposed to the Hero-fill™ Soft-Core (7.32%) and thermomechanical compaction (8.76%) (Table 1). The only statistically significant result was that the Hero-fill™ Soft-Core technique had less leakage than lateral condensation ($P < 0.05$) (Fig. 1).

The mean dye penetration surface ratio was calculated for all slices at 500 μm (level 1), 1000 μm (level 2) and 1500 μm (level 3) from the apical region in each group of 20 teeth (Table 2).

At each observation level, lateral condensation had a higher dye penetration ratio but significant differences

Table 1 Apical leakage and statistical analysis for each obturation technique

	Hero-fill™ Soft-Core (HSC)	Lateral condensation (LC)	Thermomechanical compaction (TMC)
Mean	7.32%	22.28%	8.76%
SD	8.98	19.27	9.12

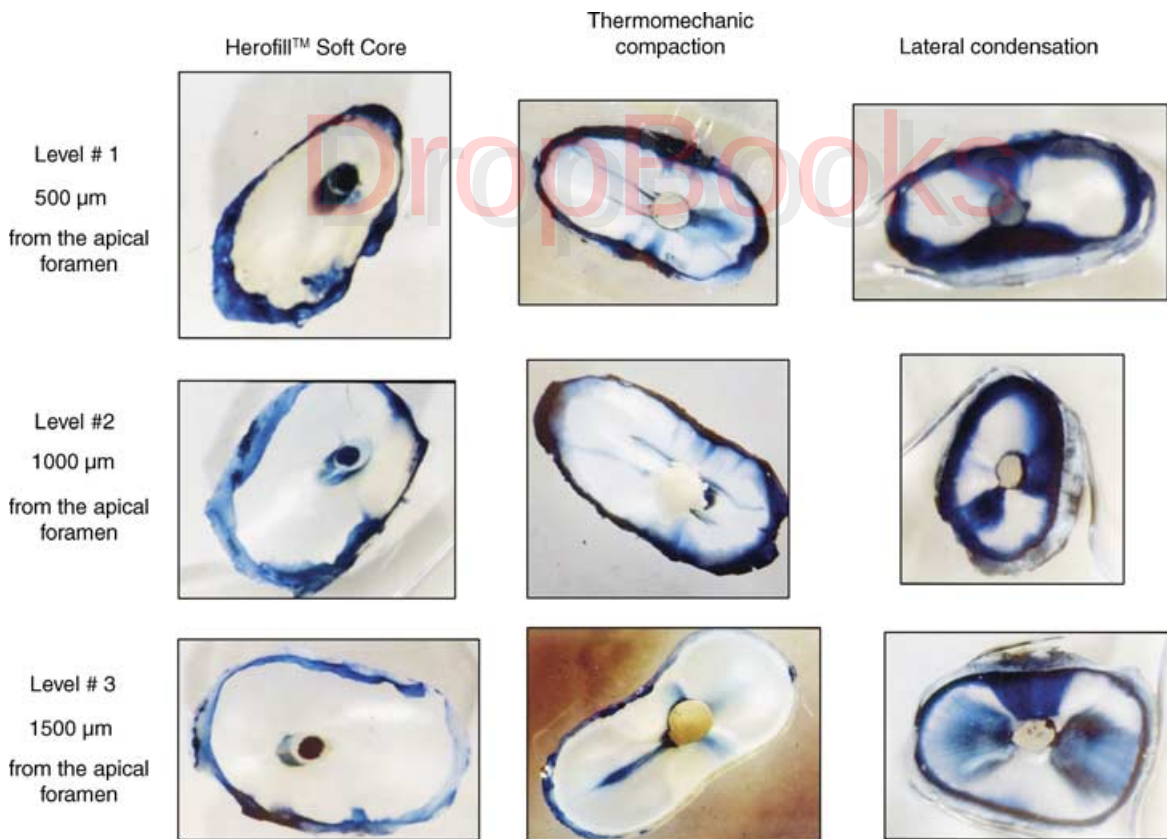


Figure 1 Microscopic observations of the dye penetration for the three obturation techniques at different apical levels.

Table 2 Apical leakage and statistical analysis at each observation level (mean ratio of infiltrated surface/total dentinal surface)

	Herofill™ Soft-Core (HSC)	Lateral condensation (LC)	Thermomechanical compaction (TMC)
Level 1 (500 µm)	6.11	25.32	10.28
Level 2 (1000 µm)	7.48	23.14	7.06
Level 3 (1500 µm)	9.40	24.30	7.50

(Table 2) were found only between the Herofill™ Soft-Core method and the lateral condensation at the 500 µm level ($P < 0.05$). At the 1500 µm level, thermomechanical compaction had significantly less leakage than lateral condensation ($P < 0.05$).

Discussion

A dye penetration method was used in this study to evaluate three different obturation techniques. Lateral condensation is a universally accepted technique and it was compared to a standard thermoplasticized gutta-percha method (thermomechanical compaction) and a new coated carrier technique (Herofill™ Soft-Core).

Methylene blue is a small molecular weight dye which has a high penetration ability. It is highly sensitive to demineralization and thus can lead to observation bias in clearing techniques (Barthel *et al.* 1999). In this study, a semiautomatic quantification method was used to measure dye penetration by direct observation with no demineralization of the sample. The use of methylene blue was acceptable with this protocol. This semiquantitative surface determination of infiltrated dentine allows for horizontal tooth section of the apical region with a 500 µm observation range. A 7-day immersion period was used, as the protocol did not involve an additional active penetration device. In addition, all the canals were prepared to the same final apical size and a same operator conducted both the preparation and obturation on each tooth.

Cold lateral condensation had greater leakage than thermomechanical condensation. These observations have been noted previously with a radioactive penetration dye (Haikel *et al.* 2000) and using passive India ink penetration (Gilhooly *et al.* 2001). The Herofill™ Soft-Core technique had significantly less leakage than lateral condensation. De Moor & Martens (1999) compared Herofill Soft-Core with cold lateral and a hybrid condensation method; the leakage analysis involved a linear penetration of dye after acid demineralization and clearing. They concluded that lateral condensation and the

hybrid condensation methods have less leakage than the Herofill Soft-Core.

The Herofill™ Soft-Core system appears comparable with the Thermafil system, both involve: a central carrier overlaid with α -phase gutta-percha, the use of a verifier and a gutta-percha heating device. Contradictory results have been reported between Thermafil obturation technique and lateral compaction which can exhibit less (Gilbert *et al.* 2001) or more (Dummer *et al.* 1993, Baumgardner *et al.* 1995) apical leakage while using passive dye penetration. These discrepancies in literature may be related to some variation in the root-canal preparation. Recent studies (Gilbert *et al.* 2001, Gilhooly *et al.* 2000, 2001) involved the crown-down technique with different taper instruments, whereas previous reports (Dalat & Spangberg 1993, Dummer *et al.* 1993, Baumgardner *et al.* 1995, De Moor & Martens 1999) using the step-back preparation with 2% taper manual files.

In the present study, a soft core thermoplasticized gutta-percha obturation system created a better apical seal than conventional cold lateral condensation. However, the clinical relevance of this *in vitro* study must be viewed with caution.

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